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CHARACTERISTICS OF THREE AND FOUR-WHEELED ALL-TERRAIN VEHICLE ACCIDENTS IN QUEBEC

by

André Delisle,[1]
Claire Laberge-Nadeau,[2]
and
Bruce Brown[3]

[1] Département de Santé communautaire, Hôtel-Dieu de St-Jérôme, St-Jérôme, Quebec.

[2] Associate Professor, département de Médecine sociale et préventive, and Affiliated Professor, Centre de recherche sur les transports, Université de Montréal, Montreal, Quebec.

[3] Département de Santé communautaire, Hôpital Charles-Lemoyne, Greenfield Park, Quebec.

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ABSTRACT

During a seven-month survey from May to November 1985, 624 victims injured from three or four-wheeled all-terrain vehicles (A.T.V.s) were observed in the emergency rooms of 10 regional hospitals in Quebec. A total of 1,100 injuries were identified, including 3 fatal and 104 serious to critical injuries (AIS > 3). These injuries were to the lower limb (29%), the upper limb (28%), the head, neck and face (26%), and the thorax, abdomen and pelvis (18%). Close to one half (45%) of the victims were aged 19 years old and less; 54% reported wearing helmets. Ten percent of the victims were hospitalized for an average period of 8 days. In 70% of the cases, the vehicle overturned: half of these vehicles turned on the side, 27% toward the back, and 19% flipped forward. Two thirds of persons injured were involved in accidents in which no external objects were hit by the vehicle; these accidents typically involved vehicle overturns, both on hills and on level ground. Ninety-five percent of the vehicles were in good mechanical condition. The use of these vehicles presents a danger whether used by a child or an adult, by an experienced or an inexperienced rider. The average user may not be aware that three and four-wheeled A.T.V.s demand considerable skill and caution.

Key words : all-terrain vehicles, three-wheeler, four-wheeler, trauma.

RÉSUMÉ

Durant une enquête conduite du mois de mai au mois de novembre 1985, 624 victimes blessées par des trimotos ou des quadrimotos ont été observées dans les départements d'urgence de 10 hôpitaux régionaux du Québec. Un total de 1 100 blessures ont été identifiées incluant 3 blessures mortelles et 104 blessures sévères ou critiques (AIS > 3). Ces blessures ont été localisées aux membres inférieurs (29%), aux membres supérieurs (28%), à la tête, au cou et à la figure (26%), au thorax, à l'abdomen et à la région pelvienne (18%). Presque la moitié (45%) des victimes étaient âgées de 19 ans et moins; 54% ont rapporté qu'ils portaient un casque de sécurité. 10% des victimes ont été hospitalisées pour une période moyenne de 8 jours. Dans 70% des cas le véhicule s'est renversé : la moitié de ces véhicules s'est renversé sur le côté, 27% vers l'arrière et 19% par en avant. Les deux tiers des personnes blessées ont été impliquées dans des accidents pour lesquels aucun objet extérieur n'a été frappé par le véhicule; ces accidents impliquent d'une façon typique le renversement du véhicule que ce soit sur une pente ou sur un terrain plat. 95% des véhicules étaient en bonne condition mécanique. L'utilisation de ces véhicules présente un danger qu'il soit utilisé par un enfant ou par un adulte, par une personne expérimentée ou un conducteur inexpérimenté. L'utilisateur moyen peut ne pas être au courant que les trimotos et les quadrimotos requièrent de la dextérité et des précautions spéciales. Nous suggérons des études plus poussées telles l'investigation en profondeur des accidents pour envisager des solutions possiblement d'ingénierie et de fabrication de ces véhicules.

Mots-clés : véhicules tout-terrain, trimotos, quadrimotos, traumatismes.

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INTRODUCTION

During the past five years, three and four wheeled all-terrain vehicles (A.T.V.s) have gained widespread popularity for recreational purposes. Associated with this phenomenon, the number of vehicles and injuries have risen dramatically. In 1985 the United States registered 238 deaths and 85,900 injured persons in A.T.V. accidents; the U.S. Product Safety Commission estimates that in 1985 there were 2.3 million of these vehicles in circulation [Marchica N., 1986]. While A.T.V. imports doubled in the U.S.A. from 1982 to 1985, the number of emergency room-treated injuries involving A.T.V.s increased ten fold [Marchica N. 1986, Rodger G. 1986].

In 1982, according to Statistics Canada, 37,012 A.T.V.s were imported into Canada. 1983 imports reached 79,010 units; 115,315 A.T.V.s were imported in 1984 and 67,693 in 1985. There are no Canadian A.T.V. manufacturers. The Québec Automobile Insurance Board estimated that in 1984 there were approximately 100,000 vehicles in circulation in the province [Simard R., 1985]. For the sake of comparison, there were 112,000 motorcycles licensed in Quebec in 1984.

Current Canadian motor vehicle standards have been established for A.T.V.s only for noise emission, vehicle identification number and lighting equipment. In Québec, as of August 1987, no special regulations were in force except vehicle licensing, since they are legally considered as motor vehicles even if, like snowmobiles, they are limited to off-road use [Desmarais P., 1985, Gagnon S., 1986].

There is increasing recognition and study of the importance of injuries related to the use of A.T.V.s; many authors report injuries including deaths and permanent disability, and raise concerns for the need to control this problem [Wiley J.J., 1986, Smith S.M. & Middaugh J.P., 1986, Michaels E., 1986, Golladay E.S. et al. 1985, Postl B.D. et al, 1987, Wiley J.J. et al., 1986].

We report here the results of a systematic survey of A.T.V. accident victims identified from emergency room records from 10 regional hospitals in rural Quebec over a seven month period. The number and severity of injuries requiring emergency room treatment are presented as well as characteristics of the involved drivers and victims, the vehicles used and the circumstances of the accident.

MATERIALS AND METHOD

The period of May 1st to November 30th 1985 was surveyed; a pilot survey done in 1984 estimated that injuries were uncommon during the winter months. All A.T.V. accident victims seeking a consultation in the emergency room of 10 regional hospitals were surveyed. The hospitals were located in Chicoutimi, Roberval, Grand-Mère, La Tuque, Rimouski, Rouyn-Noranda, and the Laurentian area with St-Eustache, Ste-Agathe, Lachute, and St-Jérôme. They serve small cities and rural areas where these vehicles are used.

During the survey period, each emergency room reported on a special form the name of the victims, the date and time of the accident, and the medical records number. It is not possible to sort out these cases from the regular emergency room registers because there is no

special code number for these types of accidents. A verification was done at each of the hospitals during the survey to assure an accurate and complete reporting of these cases. The medical record of each patient was reviewed by the first author and an assistant. To assure interobserver reliability and internal validity, each coder verified the work of the other and there were spot checks and a review of difficult cases by the chief medical records librarian and by physicians. The data extracted contained demographic characteristics plus the nature (CIM-9), location and severity (AIS-80) of injuries, the number of days in hospital and other types of hospital care.

A questionnaire administered by a telephone survey of each victim or his family gave the characteristics of each victim, driver and vehicle as well as the circumstances and perceived sequence of events that lead to the impact. The questionnaire consisted of 76 questions; the average duration of the telephone interviews was 13 minutes. These interviews were done independently from the coders. They were carried out by the Centre de sondage of the Université de Montréal which reviewed the questionnaire, and supplied and supervised trained interviewers.

Validation and computer treatment were done using the Statistical Analysis System by the Service of Studies and Analysis of the Quebec Automobile Insurance Board.

RESULTS

Complete medical records were reviewed for 624 patients with A.T.V. related injuries; 27 cases had been discarded because of incomplete information. The injury analysis was carried out on 624 medical records. The analysis of the telephone survey questionnaire was completed on 526 of these cases, for a response rate of 84%.

Characteristics of injuries

For the 624 cases, 1,100 injuries were noted, an average of 1,8 injuries per patient. These injuries were grouped into 4 body regions as reported in Table 1.

Table 1

A.T.V. INJURIES ACCORDING TO THEIR NATURE AND BODY REGION

Nature \ Body Region	Lower Limbs	Upper Limbs	Head, Neck, Face	Trunk	Total
Fracture	71	135	73	32	311
	23%	43%	24%	10%	100%
	22%	44%	26%	16%	28%
Contusion	102	65	35	92	294
	35%	22%	12%	31%	100%
	32%	21%	12%	47%	27%
Laceration	42	18	98	13	171
	25%	10%	57%	8%	100%
	13%	6%	35%	7%	16%
Abrasion	60	44	32	34	170
	35%	26%	19%	20%	100%
	19%	14%	11%	17%	16%
Sprain, Dislocation	42	43	9	14	108
	39%	40%	8%	13%	100%
	13%	14%	3%	7%	10%
Internal Injury	0	0	34	12	46
			74%	26%	100%
			12%	6%	4%
TOTAL	317	305	281	197	1100
	29%	28%	26%	18%	100%
	100%	100%	100%	100%	100%

The upper percentages are calculated horizontally, the lower percentages are calculated vertically.

The nature and location of the injuries were distributed as follows: 29% of the injuries were to the lower limbs, 28% to the upper limbs, 26% to the head, neck and face and 18% to the thorax, abdomen and pelvis; fractures were diagnosed in 28% of the cases and they affected mostly the upper limbs (43%). Contusions appeared mostly (66%) on the lower limbs and trunk area; lacerations involved primarily (57%) the head, neck and face, and abrasions were on the limbs (61%). Sprains and dislocations accounted for 10% of all injuries. Internal trauma counted for 4% of all injuries and most involved the head and neck (74%).

The severity of the injuries appeared as follows: minor (AIS 1) in 65% of all injuries, moderate (AIS 2) in 25%, serious to critical in 10% (AIS 3-4-5) and fatal in 0,3%. If one considers only the injuries to the head, the severity increases; 12% serious or severe, and 0,7% (2 cases) being fatal. As far as injuries to the trunk are concerned, 81% were minor, and 0,5% (one case) fatal. Ten percent of extremity injuries were serious (AIS 3).

The description of the three victims who sustained fatal injuries is as follows: A girl, 4 years old, sustained an open cranial fracture. The four wheeler on which she was a passenger overturned and crushed the victim. A 32 year old man had a cervical spinal cord section. He was found at the bottom of a hill, in a sand pit, on the side of his three wheeler; his 7 years old son, who was a passenger, was not injured. A two year old boy had an internal thoracic injury; the mother driving with her two children as passengers saw her A.T.V. flip backwards while driving up a hill, crushing her child.

Table 2

AGE AND SEX OF A.T.V. VICTIMS

Sex / Age	Male		Female		Total	
	No.	%	No.	%	No.	%
Less than 10 years old	**25**	5	**12**	8	**37**	6
10 to 14 years old	**69**	15	**33**	23	**102**	16
15 to 19 years old	**100**	21	**40**	27	**140**	22
20 to 29 years old	**123**	26	**34**	23	**157**	25
30 to 39 years old	**86**	18	**19**	13	**105**	17
40 years old and up	**75**	16	**8**	6	**83**	13
TOTAL	**478**	100 77	**146**	100 23	**624**	100 100

Characteristics of the victims

The age and sex distribution of victims is shown in Table 2. Forty-four percent of victims were 19 years old and less and 22% were 14 years old or younger; the mean age is 25.

The severity of the injuries per age group shows that half (51%) of the serious injuries were observed amongst those 19 years old and less whereas only 44% of all victims were in this age group. Men were injured in 77% of the cases and registered the most serious injuries: 90% of the serious, 100% of the critical ones. Female victims were generally younger than male victims.

Most of the injured were drivers of A.T.V.s (78%); 21% were passengers despite the fact that an A.T.V. is designed to bear a driver only; 44% of the victims aged 14 years old and less were passengers. Women are more represented as passengers than men: 44% versus 14%. The distribution and severity of injuries were similar for drivers and passengers.

Utilization of A.T.V.s

Recreational touring was the most prevalent reason for A.T.V. utilization at the moment of injury, appearing in 78% of the cases. The others used it for the following reasons: 11% for travel, 7% for fishing or hunting, 3% for work and 1% for racing.

Protection devices used

Close to half of the patients (45%) declared not having worn any helmet at the time of impact; this representation increased to 63% for those who registered a head, neck or face injury. Eighty-nine percent had long pants, 67% had a long sleeve shirt or jacket and 61% wore boots. Twenty-nine percent said that they wore protective glasses or visor.

Cross tabulation with age, sex and function of the patient upon impact revealed that older patients were wearing protective clothing or helmet more often than younger people, men more than women, and drivers (60% had at least one of the protective items scored) more than passengers (43%). The pattern that emerges is that older men wear safety devices while driving A.T.V.s.

Hospitalizations, time off normal occupation

The questionnaire revealed that 333 victims, 63% of respondents, had to interrupt their normal occupations following their injury. Eighty-two persons (25%) reported suspension of normal activities for three months and over; 92 persons (28%) had to suspend them during one or two months. One hundred and forty men (56%) had to interrupt normal activities for more than one month, compared to 34 (41%) of women.

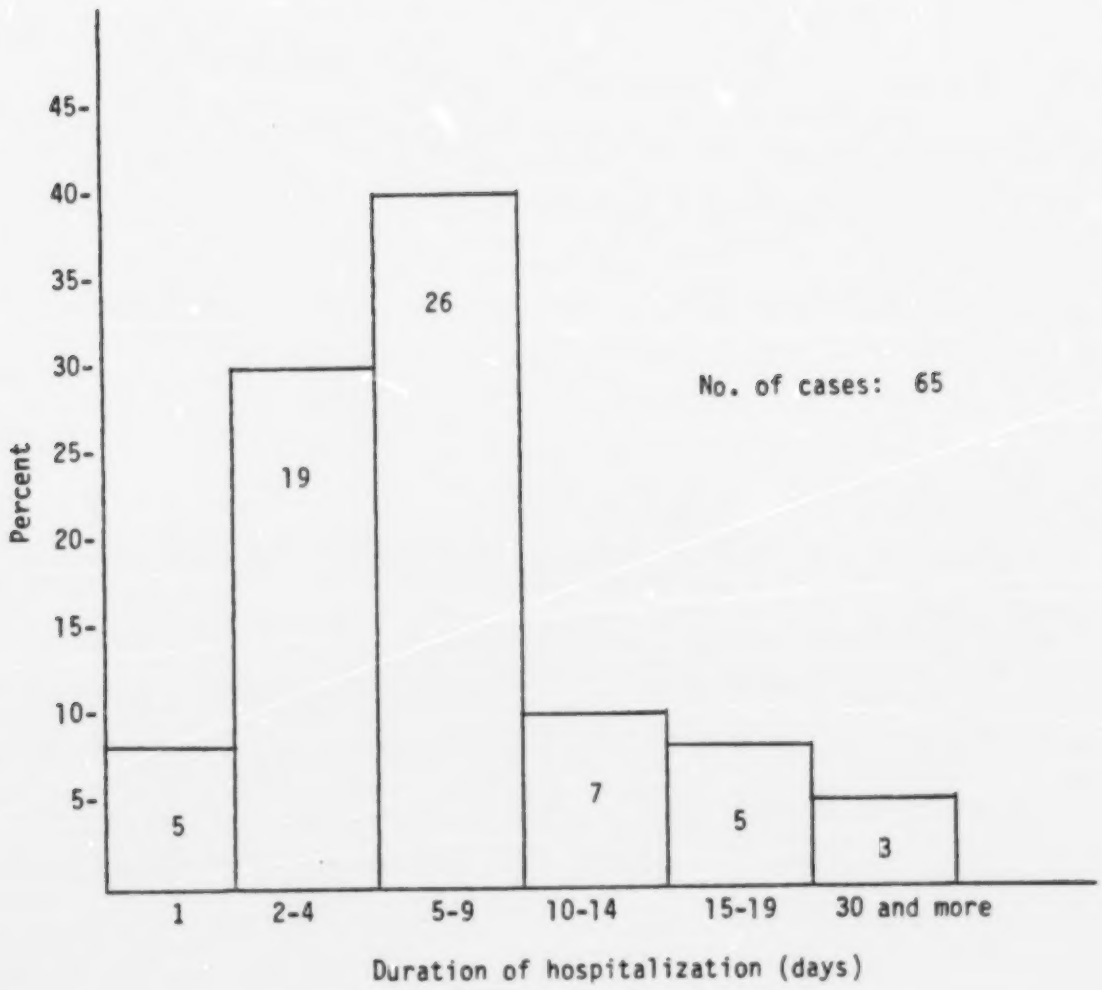
Ninety-one patients, mostly men, received salary compensation from Quebec Automobile Insurance Board (76 cases) and from workmen's compensation (15 cases).

Transportation to the emergency room was by ambulance for 10% of cases and the remainder by private citizens' vehicles except one patient who was taken to hospital in a police patrol car.

Figure 1 shows that a total of 625 hospital days were shared by 65 victims (10%), one person staying 116 days. Excluding this case, the average occupation was 8 days per person. Twelve percent of men were hospitalized compared to 5% of women. This is in line with the injury severity found. There was no significant difference in hospitalization amongst age groups.

Figure 1

DISTRIBUTION (%) OF A.T.V. VICTIMS ACCORDING TO THE DURATION OF HOSPITALIZATION



Drivers' characteristics

Seventy-eight percent of the victims were drivers; 92 drivers (18%) were 14 years old or less, 25% were 15 to 19 years old, 27% were 20-29 years old, 17% between 30-39 years old and 14% were 40 years old and up. The mean age of the drivers was 25, the same as all victims. Most of the drivers (82%) were men. We noted that women drivers were relatively younger than men. Tiredness was reported by 12% of the drivers, 7% reported having taken alcohol and 2% (12 cases) had taken medication, drugs or had a physical handicap.

We asked about the experience of driving A.T.V.s and the results were interesting. One out of ten had his accident on the very first ride; 20% of women were driving these vehicles for the first time compared to 8% of men. In spite of this, the majority of drivers (56%) had at least one year of experience with A.T.V.s.

Vehicle characteristics

Three-wheeled A.T.V.s accounted for 88% of the 526 cases, and four-wheeled, 12%. The distribution of the 1,043 injuries observed was identical; 87% involved three-wheeled vehicles. The proportion of severe injuries differed as a function of the type of vehicle involved; 16% of the injuries of four-wheeler vehicle users were serious or severe compared to 9% of injuries for three-wheelers. This difference achieved statistical significance (chi^2, $p \leq 0,01$).

Table 3

DISTRIBUTION OF INJURIES ACCORDING TO THE BODY REGION AND TYPE OF VEHICLES

Vehicle / Body regions	Three Wheelers		Four Wheelers		Total	
	No.	%	No.	%	No.	%
Head, neck and face	217	24*	47	36*	264	25
Trunk, thorax and abdomen	167	18	21	16	188	18
Upper limbs	259	28	31	24	290	28
Lower limbs	269	30	32	24	301	29
TOTAL	912	100 87	131	100 13	1 043	100

* chi^2, $p \leq 0,01$

The distribution of injuries by body region is significantly different amongst these two types of models ($p \leq 0,05$). Table 3 shows proportionally more injuries to the head, neck and face with four-wheeler A.T.V.'s ($p \leq 0,01$).

The age of the vehicle was computed: 59% of victims were riding vehicles which were 1 year old or less and 7% of 4 years and over. Noting that these vehicles are generally quite new, it is not surprising that no special defects were reported in 95% of the cases. Fourteen cases reported braking defects, 5 tire problems and 4 an accelerator defect. The majority of victims (65%) were not the owners of the A.T.V.s.

Circumstances of the impact

June, July and August were the most frequent months for accidents, the peak being in August. Sixty-five percent of injuries occurred on Friday, Saturday and Sunday. As for time of day, 62% occurred between noon and 6 P.M.; 82% occurred in full day-light, and 10% at night. As for location, 36% were on a forest path, 19% on a public road and 18% on a private road. Circulation of A.T.V.s on public roads is prohibited except for crossing or for emergency purposes, and they must be specially licensed for these conditions.

The land was dry in 79% of the 526 interviewed cases. More than half were driving on a rough surface with holes and bumps. Forty-three percent (225 cases) occurred on hills amongst which 138 cases were going uphill. Twenty-seven percent of all cases occurred while on a curve. Severity of injuries did not show any pattern whether on a hill or a flat path. Amongst all victims (drivers and passengers) 58% were injured while riding during less than 30 minutes, 39% less than 15 minutes.

The reported speeds were as follows: 52%, 30km/h and less amongst which half reported 10km/h less. Young drivers reported higher speeds and drivers over 40 years old reported the lowest speeds. The speed reported was higher for three wheelers than for four wheelers ($p \leqslant 0{,}001$). Severity of injuries was independent of the reported speed. Although these vehicles are sold for only one person, 27% of the victims were not alone on the moving vehicles. Female drivers were more frequently accompanied by other occupants (47% versus 28% for male drivers). It is to be noted that 65% of the victims were ejected from their vehicles on impact.

Table 4

TYPE OF A.T.V. ACCIDENT AS A FUNCTION OF GROUND SLOPE

Accident type	Ground Slope				Total	
	Hill		Level ground			
	No.	%	No.	%	No.	%
No collision	162	72	184	62	346	66
With collision	63	28	113	38	176	34
Total	225	100	297	100	522	100

As shown in Table 4, 66% of persons injured were involved in accidents in which no external objects were hit by the vehicle; these accidents typically involved vehicle overturns, both on hills and on level ground. Four wheelers were more frequently involved in non collision crashes (77% versus 65% $p \leqslant 0,1$). One out of four vehicles hit a fixed object, namely a rock (56 cases) a tree (32 cases) and the rest a branch, a post, a fence, etc. Forty-four cases (8%) hit another vehicle in movement.

As far as the dynamics of A.T.V. is concerned, it is worth noting that with 69% of the victims, the vehicle overturned: half on the side, 27% toward the back, 19% flipping forward. This involved more three wheelers (72%) than four wheelers (55%) ($p \leqslant 0,01$). The type of turnover was however different since for three wheelers, 53% overturned on the side, while for four wheelers, 52% overturned toward the back ($p \leqslant 0,1$).

Table 5

SEVERE INJURY ACCIDENT* CHARACTERISTICS FOR THREE AND FOUR WHEELED VEHICLES

	Three-wheeled vehicle	Four-wheeled vehicle
Collision categories		
. No collision reported with any external object	40	6
. Collision with fixed object	12	3
. Collision with another motorized vehicle	11	2
. Unspecified	4	3
Reported vehicle speed		
. $\leqslant$ 10 km/h	7	7
. 11 - 30 km/h	16	1
. $\geqslant$ 31 km/h	34	1
. Unspecified	10	5

* MAIS $\geqslant$ 3

We present in Table 5 the results reported by the 81 victims with severe injuries, MAIS = 3, 4, 5 or 6 for which vehicle type information was available. The majority of severely injured victims were aged 19 years of less, and the most common form of accident occured without the vehicle striking any identified external fixed object; these accidents typically involved vehicle overturns.

Table 6

THREE AND FOUR WHEELED VEHICLE SEVERE* INJURY-PRODUCING ACCIDENTS AS A FUNCTION OF VEHICLE OVERTURNING STATUS

	Three Wheelers vehicles	Four Wheelers vehicles	Total
No vehicle overturn reported	14	5	19
Overturn - forwards	14	0	14
Overturn - to the side	22	2	24
Overturn - backwards	9	4	13
Overturn - unspecified direction	3	1	4
TOTAL	62	12	74**

* MAIS = 3, 4, 5 or 6

** For 10 other cases, vehicle status or overturn status was not specified

In Table 6 we classify these collisions as a function of the occurence of vehicle overturns. For three-wheeled vehicles, of the 48 victims severely injured during vehicle roll-over accidents, 36 did so either forwards or to the side. Nine were involved in backwards flips. The pattern shown for the four-wheeled vehicles was different; of the 6 cases of overturns for which we have information, 4 were from backwards flips. Each of the 3 cases of four-wheeled vehicle accidents producing severe injury without collision involved the vehicle flipping backwards while climbing or traversing a slope, with the vehicle falling onto and crushing the victim. We identified overall 6 cases of vehicle overturns

associated with severe injuries for four-wheeled vehicles; in each case the most severe injury was produced when the vehicle fell onto the victim. The majority of these collisions occurred at very low reported speed, typically less than 10 km per hour.

There were 48 cases of three-wheeled vehicle overturns associated with severe injury. In 25 of these cases (52%), injury resulted from the vehicle itself; in all cases except one, the vehicle fell onto the victim.

When all A.T.V. severe injury victims reports are combined, of the 74 respondents, 38 (51%) report that their injuries resulted from being hit by the A.T.V.

DISCUSSION

We have reviewed the hospital records of over 600 patients identified in a systematic survey of the emergency rooms of 10 rural hospitals in Quebec over a seven month period. Telephone interviews were carried out with over 500 of the victims or their families concerning the circumstances of the injury producing events. Three deaths were identified from the hospital-based review, roughly 10% of victims had serious to critical (AIS $\geq$ 3) injuries and a similar number required hospitalization. Ninety-one victims (17% of interviewees) received salary compensation for temporary disability.

This study first underlines the importance of this problem in a relatively small population. These 10 hospitals have a total of 1,901 short stay beds, and represent 7% of all short stay beds in the province of Quebec. There are 161 hospital based emergency rooms in Quebec. We have estimated that our catchment population is less than 500,000 persons. U.S. C.P.S.C. has reported rates of emergency room visits, based on the number of vehicles in use in the United States in 1984, suggesting that A.T.V.-related visits are roughly twice as frequent as trail-bike visits and about six times as frequent as those involving snowmobiles [U.S. Federal Register, 1985, Coninx P., 1986]. Other authors have underlined the difficulties involved in identifying and quantifying appropriate exposure denominators [C.D.C., M.M.W.R., 1985]. The same limitation applies to our study.

The lack of stability of the three wheeled A.T.V.s is frequently cited as an important factor in accidents [Stevens W.S., 1986, Deppa R.W., 1984, Deppa R.W., 1986, Doyle Haynes C., 1986, Lawton L.J., 1987]. A high center of gravity, the lack of mechanical suspension and the lack of a differential for the driving rear-axle, all have been cited as contributing to acccidents. The turning manoeuver is complex, differing from any other vehicle with which drivers are likely to have had prior experience; the recommendations of the Canadian A.T.V. Distributor Council in their pamphlet, "The Great Adventure", read as follows:

"As you turn the handle bars in the direction of the turn, shift your body weight forward and to the outside of the turn (...) while leaning your upper body in slighly. Be sure to maintain throttle through the turn. In turning the objective is to reduce weight on the inside rear wheel by shifting your body weight. (...).

If you do not follow this technique, the A.T.V. may tend to plow straight ahead, resisting your efforts to steer with the handle bars. (...)."

Lawton explains more clearly the difficult task involved:

"The lack of differential, plus the soft tires, enhances the vehicle's straightforward motion and its resistance to turning with the use of the handle bars only. In order to turn, therefore, the rider must load (by pushing down) the outside foot peg, lightening the weight on the inside tire, then lean forward and into the turn to balance the machine. The unweighted tire will then spin a bit on soft ground, allowing completion of the turn. On a firm surface such as pavement, however, the tire will not spin, and this makes turning quite difficult. Turning on hills involves an even more sophisticated sense of the machine's balance, requiring special techniques that the rider must master".

Mastery of this and other techniques frequently overwhelm new drivers; 20% of women responding to our survey stated that their injuries occurred on their first day on an A.T.V. (vs 8% for men). The US CPSC study noted 26% of riders injured had less than one month experience with A.T.V.s [Newman, 1985].

We confirm the findings of other authors of the relative frequency of head-injuries among our severely injured users; 33 (23%) of our series of severely injured users reported head and neck injuries. Helmet use was reported overall by 55% of the 526 respondents, but only by 37% of respondants had head with neck injuries.

The importance of injuries to passengers is to be noted in spite of the fact that these vehicles are designed for a single user. Neither three nor four-wheeled A.T.V.s are designed to carry passengers. Similar findings have been noted also by other authors and have served as a basis for legislative recommendations made by the Accident Prevention Committee of the Canadian Pediatric Society to ban use of the vehicles by children under age 14, and to restrict use of the vehicle to the drivers only. This group also recommends mandatory use of helmets, compulsory licensing and insurance, banning of promotional materials depicting the use of off-road vehicles by children under 14 years of age in adventurous or dangerous activities, and safety regulations to govern the manufacture and sale of off-road vehicles (Accident Prevention Committee, Canadian Ped. Society).

We feel that our results raises serious safety concerns for four-wheeled vehicles, as well as confirming previous findings concerning three-wheeled vehicles. The pattern of severe injury-producing collisions we have noted in this series involving four-wheeled vehicles suggests to us an opportunity for engineering solutions through more detailed accident reconstruction; in at least one-half of these twelve collisions the vehicle itself crushed the victim, and backwards flips at low speed accounted for four of the cases. The specificity of these injury mechanisms suggests possible injury control measures through design changes. The frequency of backwards flips might be influenced by power train changes or weight distribution changes, and the likelihood of severe injury should an overturn occur could possibly be limited by the use of roll-over bars or changes to seat design.

We would like to underline that over two-thirds of respondents state that their injuries resulted from accidents, such as vehicle over-turns, in which no external objects were struck by the vehicle. Few mechanical defects were identified, and the majority of respondents reported driving at 30 km/h or less. Thus typically injuries resulted at low speed, involved vehicle overturning on level ground or hills related to "faulty" driver manoeuvers; very inexperienced users are frequently involved, but over half of our injured users had greater than one year of experience. This pattern and frequency of injury producing events is of great concern to us; it would appear that dangers inherent in the design of these vehicles are not being effectively recognized by users, both inexperienced and experienced. Although problems of injuries resulting from A.T.V. use have been identified for several years,

the pattern we observe in 1985 underlines continuing ineffective control.

CONCLUSION

There is increasing recognition of the growing frequency and the severity of A.T.V. related injuries across North America. We underline the frequency of injuries resulting from low-speed accidents on both level ground and hills, occurring without vehicular collisions with external objects, involving both very inexperienced and experienced drivers; these observations are consistent with the view that users continue to be unable to effectively recognize the dangers associated with the instability of these vehicles. We encourage the continuing efforts to better train and inform users. We, however, feel that there is little room to be optimistic that such educational efforts will be effective in reducing injury frequency or severity, given the limited effectiveness of educational interventions in most areas of injury control (Robertson, 1983, Waller, 1985).

Legislative solutions including mandatory insurance, offer an important and probably useful and necessary path to limiting injuries related to use of these vehicles. We suggest, in addition, the use of accident reconstruction studies for possible engineering solutions.

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